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THE COPY PROTECTION OF DIGITAL AUDIO COMPACT DISCS

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FIELD OF THE INVENTION

The present invention relates to a method of copy protecting a digital audio compact disc, and to a copy protected digital audio compact disc.

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BACKGROUND OF THE INVENTION

Digital audio compact discs (CD-DA) which carry music or other audio can be played or read by more sophisticated apparatus, such as CD-ROM drives. This means, for example, that the data on a CD-DA acquired by a user may be read into a PC by way of its ROM drive and thus copied onto another disc or other recording medium. The increasing availability of recorders able to write to CDs is therefore an enormous threat to the music industry.

The present invention seeks to provide a method of copy protecting a digital audio compact disc.

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SUMMARY OF THE INVENTION

According to a first aspect of the present invention there is provided a method of copy protecting a digital audio compact disc, wherein control data usable by a data reader is encoded on the compact disc, the copy protection method comprising the step of rendering selected control data incorrect and/or inaccurate.

With an embodiment of the invention, the incorrect data encoded onto the CD is either inaccessible to, or not generally read by, an audio player. Therefore, a legitimate audio CD bought by a user can be played normally on an audio player. However, the incorrect data renders the CD unplayable by a data reader. This prevents copying of the data on the compact disc.

Of course, by rendering the audio compact disc unplayable on a data reader, the user is also prevented from using a CD-ROM drive, for example, legitimately simply to play the music or other audio on the disc.

In this specification the term "audio player" is used to refer to players and drives arranged to play the audio data on a digital audio compact disc. Such players will generally be commercially available CD music players which function solely to play the music or other audio on the CD. It is required that the incorrect

data encoded onto the CD does not generally impinge on, or affect the normal operation of, such an "audio player".

In this specification, the term "data reader" is used to refer to all players and drives which are able to read the data on the disc, for example, by extracting or otherwise accessing the data on the disc. Such players will include, therefore, CD-ROM drives. Generally, and as acknowledged above, a CD-ROM drive, for example, will not only be prevented from making a usable copy of a legitimate CD-DA, but will generally be prevented from playing a legitimate CD-DA.

In one embodiment of a method of the invention, the data encoded on the compact disc which has been rendered incorrect is navigation and/or timing data.

For example, data identifying the position on the disc of the Lead-Out is rendered incorrect in the Lead-In of the disc. Thus, data in the Lead-In which indicates the Atime at the start of the Lead-Out may be rendered incorrect. For example, the data in the Lead-In may show the Atime at the start of the Lead-Out to be zero. Alternatively, the data in the Lead-In may have a value for the Atime at the start of the Lead-Out which occurs during a first audio track on the compact disc.

Additionally and/or alternatively, the data on the CD defining the nature of the tracks is rendered incorrect.

In a preferred embodiment, the data on the CD identifying the nature of the tracks incorrectly identifies each audio track as a data track.

In a preferred embodiment of a method of the invention, the data encoded on the disc which is rendered incorrect is data in the Table of Contents (TOC) of the compact disc.

Preferably, the control data encoded on the compact disc is altered, to render it incorrect, prior to mastering of the disc.

The present invention also extends to a copy protected digital audio compact disc, wherein control data usable by a data reader is encoded on the compact disc, and wherein selected control data has been rendered incorrect and/or inaccurate.

Preferably, the incorrect data encoded onto the compact disc is either inaccessible to, or not generally read by, an audio player. This enables the copy protected disc to be played normally on an audio player. However, the data encoded on a copy protected compact disc renders the disc generally unplayable by a data reader. This prevents the use of a data reader to extract or read the data on the disc, whereby copying of the disc is also prevented. Of course, it is no longer possible to use a CD-ROM drive, for example, to play the audio on a legitimately acquired copy protected disc,

In an embodiment, the incorrect control data on the copy protected disc is navigation and/or timing data.

For example, incorrect control data is provided in the Lead-In, and identifies the position on the disc of the Lead-Out. Thus, the incorrect control data in the Lead-In may indicate incorrectly the Atime at the start of the Lead-Out. For example, the incorrect control data in the Lead-In may show the Atime at the start of the Lead-Out to be zero.

Alternatively, the incorrect control data in the Lead-In may have a value for the Atime at the start of the Lead-Out which occurs during a first audio track on the compact disc.

Additionally and/or alternatively, a copy protected digital audio compact disc of the invention may have incorrect control data encoded onto the disc which defines the nature of the tracks on the disc.

In an embodiment, the incorrect control data incorrectly identifies each audio track as a data track.

A copy protected digital audio compact disc of the invention may have incorrect control data encoded thereon which is control data in the Table of Contents (TOC) of the disc.

a BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the present invention will hereinafter be described, by way of example, with reference to the accompanying drawings, in which:-

Figure 1 shows schematically a compact disc showing the spiral data track,

Figure 2 shows the structure of a frame of data encoded on a CD,

Figure 3 illustrates the general data format of the Q-subchannel,

Figure 4 shows the format of the data for the Q-subchannel according to mode,

Figure 5 shows graphically both Atime and Ttime on a compact disc,

Figure 6a shows an example of the track definition, with the Table of Contents, of a CD-DA, and

Figure 6b shows the Table of Contents of the CD-DA of Figure 6a when the disc has been copy protected.

a DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A digital audio compact disc (CD-DA), which carries music and is to be played on an audio player such as a conventional CD disc player, is made and recorded to a standard format known as the *Red Book* standards. As well as defining physical properties of the disc, such as its dimensions, and its optical properties, such as the laser wavelength, the *Red Book* also defines the signal format and the data encoding to be used.

As is well known, the use of the *Red Book* standards ensures that any CD-DA produced to those standards will play on any audio player produced to those standards.

Figure 1 shows schematically the spiral track 4 on a CD 6. This spiral track 4 on a CD-DA is divided into a Lead-In 8, a number of successive music or audio tracks as 10, and a Lead-Out 12. The Lead-In track 8 includes a Table of Contents (TOC) which identifies for the audio player the tracks to follow, whilst the Lead-Out 12 gives notice that the track 4 is to end.

An audio player always accesses the Lead-In track 8 on start up. The music tracks may then be played consecutively as the read head follows the track 4 from Lead-In to Lead-Out. Alternatively, the player navigates the read head to the beginning of each audio track as required.

All compact disc players and readers are programmed not to move the read head beyond the start of the Lead-Out track 12. This is to protect the read head.

To the naked eye, a CD-ROM looks exactly the same as a CD-DA and has the same spiral track divided into sectors. However, data readers, such as CD-ROM drives, are much more sophisticated and are enabled to read data, and process information, from each sector of the compact disc according to the nature of that data or information. A data reader can navigate by reading information from each sector whereby the read head can be driven to access any appropriate part of the spiral track 4 as required.

To ensure that any data reader can read any CD-ROM, the compact discs and readers are also made to standards known, in this case, as the *Yellow Book* standards. These *Yellow Book* standards incorporate, but extend, the *Red Book* standards. Hence, a data reader, such as a CD-ROM drive, can be controlled to play a CD-DA.

The ability of a data reader to access, extract, or otherwise read the data on a CD-DA provides a problem for the music industry. A user can use a CD-ROM drive to read the data from an audio disc, for example, into a computer file, and then that data can be copied. The increasing availability of recorders able to record onto compact discs means that individuals and organisations now have easy access to technology for making perfect copies of audio compact discs. This is of great concern to the music industry.

An audio player, be it a dedicated compact disc music player, or a more sophisticated CD-ROM drive when controlled to play an audio disc, only looks for and uses data encoded to *Red Book* standards. What is more, if there appears to be an inaccuracy in the data, an audio player will generally continue to play rather than trying to correct the error. For example, if the read head has

navigated to the start of a track and commenced to play that track, the audio player will continue to play that track to its end, even if it becomes apparent that there is some error in the timing information, for example. By contrast, a data reader is arranged to identify and correct errors.

The present invention therefore suggests that errors should be deliberately introduced into the encoded data. For example, errors may be introduced into the *Red Book* data, but the introduced errors should be of a type which are generally transparent to an audio player. Alternatively, the audio discs may be encoded with selected and incorrect *Yellow Book* data which is not utilised by an audio player. In each case, the errors are chosen such that a data reader is unable to read or play the audio disc. It will be appreciated that a system of the invention has the disadvantage that a user cannot play a legitimately acquired audio disc having the copy protection on a data reader in a legitimate manner, that is, simply to play the music recorded on the disc. However, in view of the potential losses from piracy, the music industry is willing to accept that disadvantage.

As the data encoding on a CD-DA and on a CD-ROM is well known and in accordance with the appropriate standards, it is not necessary to describe it in detail herein.

Briefly, the data on a CD is encoded into frames by EFM (eight to fourteen modulation). Figure 2 shows the format of a frame, and as is apparent therefrom, each frame has sync data, sub-code bits providing control and display symbols, data bits and parity bits. Each frame includes 24 bytes of data, which, for a CD-DA, is audio data.

There are 8 sub-code bits contained in every frame and designated as P,Q,R,S,T,U,V and W. Generally only the P and Q sub-code bits are used in the audio format. The standard requires that 98 of the frames of Figure 2 are grouped into a sector, and the sub-code bits from the 98 frames are collected to form sub-code blocks. That is, each sub-code block is constructed a byte at a time from 98 successive frames. In this way, 8 different subchannels, P to W, are formed. These subchannels contain control data for the disc. The P- and

Q- subchannels incorporate timing and navigation data for the tracks on the disc, and generally are the only subchannels utilised on an audio disc.

The data format for a Q-subchannel block assembled from 98 successive frames is indicated in Figure 3. As is apparent, the start of the subchannel block is indicated by the appearance of sync patterns S0 and S1 as the first 2 symbols. The next data bits are control bits to define the contents of a track. Thus, the control bits might identify audio content or data content. There then follows address information, ADR, which specifies one of four modes for the Q-data bits. 72 bits of Q-data succeed the address information, and then there are 16 CRC, or check, bits which are used for error detection on the control, address and Q-data bits.

Figure 4 illustrates the data content of a Q-subchannel block in each of the four modes designated by the address information, ADR. In Mode 0, all of the Q-data has a value of zero. In Mode 0, the data of the P-subchannel is also set to zero. In Mode 2, the Q-data comprises a catalogue number for the disc, such as a bar code of the Universal Product Code. In addition, in Mode 2 the Atime count from adjacent blocks is continued. Mode 3 is used to give ISR code for identifying each music track. In addition, and as is illustrated, in Mode 3 the absolute time count, Atime, is continued.

As indicated in Figure 4, in Mode 1 the Q-data in each subchannel block contains program and time information for individual audio tracks and for the information area of the disc. As is illustrated, there is a different format for the Q-data for the Lead-In area to that within the program and Lead-Out areas. However, in both formats in Mode 1, the Q-data gives information as to the time along a track. The running time of a track is referred to as the Ttime, is in minutes, seconds and frames, and TMin, TSec and TFrame are all components of Ttime. In the program and Lead-Out areas, the Q-data additionally includes information about the absolute time, Atime, on the disc in minutes, seconds and frames, and Amin, Asec and Aframe are all components of Atime.

Figure 5 shows graphically how Atime and Ttime vary across a disc. Atime is the absolute time across the disc and starts at zero at the beginning of the program area. Ttime is the running time within each track and thus starts at

zero at the beginning of each track. Thus, and as illustrated in Figure 5, Atime increases monotonically across the disc whilst Ttime increases along each individual track. As is also illustrated in Figure 5, the P-subchannel includes flags F which each indicate the start of a respective track. The P-subchannel flags also designate the Lead-Out area.

As indicated in Figure 4, in Mode 1 each Q-subchannel block contains the next consecutive values for Atime and Ttime. When an audio player is to play an audio track, the head is navigated to the commencement of the track. The navigation may be by way of the Atime, the Ttime, and/or the P-subchannel flags, or by some combination thereof. In general, once an audio player has commenced playing a track, it will continue. Playing of the track is not generally stopped if any data errors are located, and thus the audio player effectively ignores any data errors which arise. Thus, if an audio player can be reliably navigated to the commencement of a track, it can be expected to provide a continuous audio output from that track without problem.

As set out above, in Mode 1 the Q-data provides the TOC in the Lead-In area. Part of a typical TOC is set out in table form in Figure 6a. It will be seen therefrom that each track, at 14, is given, at 16, a start address in time and in frames from the end of the Lead-In. Each track also has a logical block address (LBA) 18 which is calculated from the Atime and provides an address for the start of the track on the disc. The TOC of an audio disc also identifies the Atime from the start of the program area to the start of the Lead-Out as indicated at 20. However, the applicants have determined that generally audio players do not read or use the Lead-Out time from the TOC.

Figure 6b shows in table form part of the TOC from Figure 6a after it has been altered to copy protect the disc. Specifically, it will be seen that, at 20, the Atime from the start of the disc program area to Lead-Out has been set to zero indicating that the Lead-Out is at the commencement of the pregap of the first audio track. A data reader, therefore, accessing the disc 6 will read from the Lead-In information signifying that the disc does not have a program area and that the Lead-In is directly followed by the Lead-Out. The data reader will refuse to move the read head beyond the start of the audio track because it believes

that the first track starts within the Lead-Out. A data reader, therefore, will be unable to read or play the disc with the TOC of Figure 6b.

It will be appreciated that the values in the tables of Figures 6a and 6b are given only to illustrate how the information is manipulated to provide the copy protection. The actual values of discs in practice may differ from those shown in the tables.

The TOC of Figure 6b has been altered in a second way which also prevents proper use by a data reader of the information on the disc. In this respect, and as is apparent from Figures 6a and 6b, the tracks on the audio disc are all audio tracks as noted at 22. In the TOC of Figure 6b these tracks have been erroneously identified as data tracks. Thus, even if the data reader is manipulated to ignore the false Lead-Out information in the TOC, it is told that each of the following tracks contains digital data, rather than analog audio. Any reading of those tracks is therefore confused as the player tries to read the data but cannot find the appropriate SYNC or sector headers. Errors therefore result and the reading is unsatisfactory.

In the illustrated embodiment, the Atime has been set to zero to indicate that the Lead-Out is at the commencement of the pregap of the first audio track. It is also possible to set the Atime for the Lead-Out to an alternative, incorrect, value. Such an incorrect value will confuse a data reader and will generally prevent movement of the read head further across the disc than the position indicated by the incorrect Lead-Out time. For example, the Atime value given in the TOC for the Lead-Out might indicate a position within the first or a subsequent audio track.

Where the incorrect Atime value for the start time of the Lead-Out points to a position in the program area of the disc, a data reader may be able to access audio data on the disc at positions before that indicated by the incorrect Atime value. However, the amount of accessible audio data can be kept small. In the future, audio players may be enabled to read the Lead-Out time, for example, and in this circumstance, having the incorrect Lead-Out time identify a position within the first audio track will ensure that the audio player is able to play the copy protected disc.

The embodiments described and illustrated above identify two alterations that can be made to the data in the Lead-In to an audio disc to copy protect that disc. It will be appreciated that any data which is transparent to the audio player may be altered to prevent the operation of a data reader. Additionally and/or alternatively, data may be provided on an audio disc to prevent the generation of a digital output from the audio player. It will also be appreciated that alternative or additional errors in *Red Book* or *Yellow Book* standard data can be introduced as required.

Further modifications in or variations to the embodiments described above may be made within the scope of the appended claims of this application.